Conclusion

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Analyses of the BPTR in intact sea urchin larvae revealed that the rotation of beat plane occurs with little changes in bending wave pattern. From these analyses, we proposed two alternative models: model R, in which the whole motile apparatus rotates without changes in the internal motile activities, and model A, in which the internal activities are modulated without rotation of the whole apparatus.

Model R can be subdivided by the extent of rotating motile apparatus in two models: model R1 in which ciliated epithelial cells rotate at the boundary, and model R2, in which the basal body rotates by contraction of accessory structures, e.g. striated rootlets. The BPTR could be induced by dopamine in isolated cells held by a pipette, in which the beat plane rotates in the same manner as in larvae while the cells does not. This excludes the probability of model R1. Deformation of isolated cells in the presence of dopamine described in Part 2 clarifies that ruggedness of the epithelial surface induced by dopamine is due to contraction of the cells themselves. Cell contractility in response to dopamine might be involved in rotation of the basal body during the BPTR. If this is the case, model R2 is possible. Electron microscopical studies of the basal structure in the presence of dopamine will give insights into this problem.

Symmetrical ciliary beating observed in isolated cells under Ca^{2+}-free conditions, which is not mere flagella-type movement but repeats alternating recovery strokes in the opposite directions, may suggests a transition from the recovery stroke

of the normal beating to that of the BPTR beat by beat. This may support model A.

Little correlation between beat period and angular velocity before and after isolation indicates independent mechanisms in ciliary movement. Modulation of fluctuation in beat period induced by neurotransmitters, which is discussed to arise from that of switching of tubule sliding, indicates chemical modification of the axoneme via second messengers, e.g. Ca^{2+} and cAMP.